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Algoma Street Bridge Test

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Abstract:	Algoma street bridge in Thunder Bay, Ontario, is a two-lane bridge made of two independent frames built side-by-side. One of the frames, built in 1909, has ten continuous spans. The other, built in 1935, has nine spans. Both structures have "T" or "L" beams of reinforced concrete. Spans on both structures range from 4.2 m to 11.3 m. The deck is topped with asphalt which appears to have no waterproofing. The bridge beams are very badly deteriorated in many areas. Because the reinforcement is corroded, it may not be effectively bonded to the concrete. The slabs are in fair to good conditions in most of the spans. There are signs of water seepage through the longitudinal joint between the two structures. Because of the bridge's advanced state of deterioration, the city has decided to replace it.
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ALGOMA STREET BRIDGE TEST

Algoma street bridge is located in the city of Thunder Bay, MTC Site No. 48c-73. A view of the bridge is shown in Figure 1. The bridge is a two-lane structure comprising two independent reinforced concrete frame structures built side-by-side. The first structure was built in 1909 and consists of ten continuous spans. The second structure was built in 1935 and consists of nine spans. Both structures are reinforced concrete slabs with "T" or "L" reinforced concrete beams. The spans on both structures vary from 4.2 m (min.) to 11.3 m (max.). Details of the bridge are given in Figure 2. The deck has asphalt topping, and appears as though it is not waterproofed. The longitudinal joint between the two structures is also not waterproofed. The interior beam of the 11.3 m span frame is now being supported by a steel prop. The steel prop consists of two 300 mm deep S-type beams. The reason for the use of steel prop is not known.

The bridge beams are very badly deteriorated in many areas. The reinforcement is corroded and the bond between the reinforcement and the concrete could be ineffective. The slabs are in fair to good condition in most of the spans. There are visible signs of water seepage through the longitudinal joint between the two structures. The level of deterioration observed on the structure is illustrated in Figure 3a and 3b. Because of the advanced deteriorated state of the bridge the city has decided to replace the structure. Replacement of the bridge is due to begin in December, 1986.

Underwood McLellan Ltd evaluated the bridge in 1981 and recommended a posting load of 10 t. It was found that the beams were deficient in negative moment capacities at the midspan locations. The beams were also found to be deficient in shear resistance at the support locations. The evaluation did not allow for the structural deterioration observed at the time of evaluation. The city posted the bridge with single 10 t posting as shown in Figure 3c.

The structure was evaluated recently for OHBDC loads. The analysis was performed assuming that the bent up bars in the beams are continued over the supports. Member forces and member resistances are given in Table 1a

and 1b. Analysis showed that the beams in both structures have adequate capacity to sustain OHBDC loads. The negative moment induced at the midspan is a concern; however, the magnitude of the negative moments is not large and ranged between 50 to 75 kNm. It was assumed that the beams can sustain these moments with the minimum top reinforcements commonly provided in reinforced concrete beams. The columns were found to have adequate capacity to sustain OHBDC loads. This evaluation does not include the effects of the deterioration of the structure. It is noted that the structure has deteriorated considerably, which may have reduced the structures' resistance.

Although the bridge was slated for immediate replacement, a load test was performed to study the load capacity of the bridge. The instrumentation and the truck positions used in testing are given in Figures 4 and 5, respectively. The bridge was loaded using a Kenworth truck to a maximum of 656 kN. The strains recorded for load level 3 and for selected gauges are given in Tables 2, 3 and 4. The strain values recorded were low and did not show a clear trend. The loading of the bridge was stopped at load level 3 because of the bridge's advanced deterioration. It was feared that the structure might exhibit brittle failure.

The test results showed that, although the structure is badly deteriorated, it sustained fairly high truck loads, i.e., 68 t compared to the posted load of 10 t. The recorded strain values were low and hence could have higher load capacity than the test truck load applied.

Table 1a/ Member Forces and Member Resistances Calculated for the Old Bridge

	Factored Dead Load Force Effects		Factored Live Load Force Effects		Total		Member Resistance	
	Beam (kNm)	Column (kN)	Beam (kNm)	Column (kN)	Beam (kNm)	Column (kN)	Beam (kNm)	Column (kN)
1	50		225(-47)		275		385	
	77	211	193	372	270	583	251	
	75		173		247		251	
2	26		198(-62)		224		386	
	52	196	148	327	199	523	251	
	52		141		192		251	
3	26		181(-78)		207		386	
	75	227	251	372	326	599	484	
	76		270		346		484	
4	46		299(-88)		346		768	
	219	359	438	480	657	839	1020	
	229		554		691		1020	
5	167		461(-39)		629		1768	Not calculated. Column reinf. details not clear.
	229	359	459	479	689	838	1020	
	219		435		655		1020	
6	46		292(-88)		339		768	
	76	218	269	373	345	591	484	
	74		249		324		484	
7	26		177(-80)		203		386	
	52	187	140	325	192	512	251	
	52		151		204		251	
8	26		180(-62)		206		386	
	75	211	169	372	244	583	250	
	77		189		266		250	
9	50		234(-69)		284		385	

() Maximum negative moment induced at midspan section

Table 1b/ Member Forces and Member Resistances Calculated for the New Bridge

	Factored Dead Load Force Effects		Factored Live Load Force Effects		Total		Member Resistance	
	Beam (kNm)	Column (kN)	Beam (kNm)	Column (kN)	Beam (kNm)	Column (kN)	Beam (kNm)	Column (kN)
1	42		171(38)		213		269	
	35	140	134	287	175	427	198	
	30		119		170		198	
2	(8)		129(79)		137		269	
	128	282	287	385	415	667	691	
	141		308		449		691	
3	255		575(128)		830		927	
	278	388	467	433	745	821	890	3105
	269		470		739		890	
4	107		332(40)		439		467	
	157	282	338	363	495	645	890	Not calculated. Columns are considered adequate.
	151		319		470		890	
5	43		227(58)		270		333	
	66	182	213	290	279	472		
	63		191		254			
6	17		138(61)		155			
	47		111	262	158	413		
	46	151	118		164			
7	25		152(40)		177		Not calculated.	
	47	148	121	264	168	412		
	46		127		173			
8	21		136(43)		157			
	52	152	123	287	175	439		
	53		136		189			
9	31		159(38)		190			

() Maximum negative moment induced at the midspan section

Table 2a/ Strains Measured Under Level 3 Truck Loads

Load Level 3, Line 1

Gauge	Position No. 1	2	3	4	5	6	7	8	9
9	-8	32	-17	35	29	-11	-7	-6	-6
10	-8	-5	-12	-7	-7	-14	-12	-11	-13
11	-43	-43	-44	-43	-43	-45	-45	-45	-45
23	-21	-19	-16	-15	-18	-16	-25	-28	-26
24	-22	-20	-17	-8	-20	-9	-27	-28	-27
25	-32	-22	-9	34	-19	33	-44	-51	-47
26	-22	-22	-22	-22	-22	-23	-24	-24	-24
27	-34	-32	-24	-21	-29	-22	-40	-43	-41
28	2	2	0	2	2	1	1	1	1
29	-41	-40	-40	-40	-41	-41	-45	-46	-45
21	17	18	16	17	17	16	16	16	17
22	2	2	2	2	3	2	2	2	2
39	-11	-11	-12	-11	-10	-8	-9	-8	-9
40	-77	-79	-87	-85	-58	45	-9	80	47
41	-42	-42	-43	-42	-41	-34	-38	-31	-35
42	-43	-43	-44	-44	-41	-29	-30	-24	-28
43	-26	-25	-26	-26	-25	-25	-26	-26	-26
44	-49	-49	-50	-50	-49	-46	-46	-45	-46
45	3	3	1	3	3	3	3	3	2
46	-14	-14	-15	-14	-14	-14	-14	-14	-14

Table 2b/ Strains Measured Under Level 3 Truck Loads

Load Level 3, Line 1

Gauge	Position No. 1	2	3	4	5	6	7	8	9
12	-32	-33	-33	-33	-35	-34	-33	-33	-33
13	-6	-5	-4	-4	-4	-6	-7	-7	-7
14	-39	-40	-38	-39	-40	-37	-40	-40	-40
15	-33	-35	-32	-35	-36	-35	-36	-36	-36
16	-40	-15	-38	-4	1	-29	-44	-44	-43
17	-25	-25	-24	-25	-25	-24	-25	-25	-25
18	-39	-40	-36	-41	-41	-37	-40	-40	-40
19	-16	-16	-16	-16	-16	-16	-16	-16	-16
20	-48	-48	-46	-48	-46	-48	-49	-49	-51
31	-34	-36	-38	-39	-37	-44	-36	-39	-40
32	-40	-45	-55	-68	-56	-94	-28	-60	-65
33	-26	-26	-26	-27	-26	-26	-24	-25	-26
34	-2	-3	-3	-5	-4	-10	-5	-7	-8
35	-7	-5	-7	-6	-6	-7	-7	-7	-8
36	-54	-54	-55	-56	-55	-58	-55	-56	-57
37	-7	-6	-7	-6	-6	-7	-6	-7	-7
38	-13	-13	-14	-13	-13	-14	-14	-14	-14

Table 3a/ Strains Measured Under Level 3 Truck Loads

Load Level 3, Line 2

Gauge	Position No. 1	2	3	4	5	6	7	8	9
9	-7	8	-11	10	9	-6	-4	-3	-3
10	-20	9	-32	5	6	-28	-23	-22	-23
11	-48	-43	-49	-39	-39	-47	-46	-46	-46
23	-21	-22	-21	-21	-21	-21	-21	-22	-21
24	-23	-22	-20	-18	-21	-18	-24	-25	-24
25	-30	-28	-18	-7	-22	-7	-39	-43	-40
26	-24	-24	-22	-23	-24	-23	-24	-24	-24
27	-36	-27	-9	19	-22	19	-45	-49	-44
28	2	1	2	0	2	1	2	2	1
29	-44	-43	-39	-36	-38	-36	-50	-54	-51
21	17	17	19	18	18	18	19	18	18
22	3	2	2	3	2	2	2	2	2
39	-12	-12	-12	-13	-13	-12	-12	-11	-12
40	-80	-82	-86	-81	-73	-9	-32	12	-9
41	-45	-45	-45	-45	-43	-24	-36	-24	-31
42	-46	-47	-48	-47	-36	-12	-16	19	1
43	-26	-28	-26	-28	-26	-26	-26	-26	-27
44	-54	-55	-55	-54	-52	-19	-32	-7	-16
45	2	2	2	2	2	3	4	4	3
46	-14	-14	-14	-14	-14	-13	-13	-13	-14

Table 3b/ Strains Measured Under Level 3 Truck Loads

Load Level 3, Line 2

Gauge	Position No. 1	2	3	4	5	6	7	8	9
12	-33	-34	-33	-33	-33	-31	-32	-32	-32
13	-7	-7	-6	-6	-6	-6	-7	-6	-6
14	-40	-40	-40	-40	-40	-40	-40	-40	-40
15	-36	-36	-34	-36	-36	-36	-36	-36	-36
16	-41	-41	-31	-39	-41	-32	-39	-38	-38
17	-26	-26	-24	-25	-26	-23	-25	-25	-25
18	-42	-52	-21	-57	-54	-39	-42	-40	-40
19	-15	-16	-16	-16	-16	-16	-16	-16	-16
20	-49	-47	-49	-44	-47	-46	-56	-56	-56
31	-37	-37	-38	-39	-38	-39	-34	-37	-37
32	-42	-44	-49	-53	-49	-65	-39	-50	-52
33	-27	-27	-27	-26	-27	-24	-23	-24	-26
34	-3	-6	-9	-16	-13	-32	-4	-21	-18
35	-8	-9	-8	-9	-8	-8	-9	-8	-8
36	-56	-59	-61	-67	-65	-84	-53	-74	-73
37	-8	-8	-8	-8	-9	-9	-9	-9	-10
38	-14	-14	-14	-14	-14	-14	-12	-12	-14

Table 4a/ Strains Measured Under Level 3 Truck Loads

Load Level 3, Line 3

Gauge	Position No. 1	2	3	4	5	6	7
9	-2	-2	-2	-2	-2	-1	-1
10	-26	-25	-25	-26	-28	-28	-28
11	-47	-19	-47	-39	-46	-46	-46
23	-20	-20	-20	-20	-20	-20	-20
24	-22	-22	-22	-22	-22	-22	-22
25	-29	-31	-28	-28	-29	-31	-30
26	-23	-23	-23	-23	-23	-24	-24
27	-32	-31	-27	-28	-30	-40	-38
28	2	2	2	3	2	2	1
29	-42	-38	-27	-25	-9	-56	-54
21	18	19	23	26	26	20	20
22	4	3	5	7	4	2	2
39	-12	-13	-13	-12	-12	-14	-12
40	-78	-80	-79	-76	-76	-76	-74
41	-38	-38	-38	-36	-32	-29	-30
42	-45	-47	-49	-42	-38	-35	-38
43	-28	-27	-26	-27	-26	-26	-25
44	-58	-58	-60	-47	9	27	20
45	3	2	2	4	6	7	6
46	-14	-15	-16	-13	-9	-7	-5

Table 4b/ Strains Measured Under Level 3 Truck Loads

Load Level 3, Line 3

Gauge	Position No. 1	2	3	4	5	6	7
12	-32	-33	-32	-32	-32	-32	-32
13	-6	-6	-6	-6	-6	-6	-6
14	-39	-40	-40	-40	-40	-39	-39
15	-35	-35	-35	-35	-36	-36	-35
16	-35	-34	-35	-34	-34	-33	-33
17	-24	-25	-24	-24	-24	-24	-23
18	-41	-41	-41	-42	-42	-40	-40
19	-16	-18	-27	-28	-26	-25	-24
20	-47	-39	-6	0	-20	-56	-54
31	-36	-36	-36	-36	-36	-36	-35
32	-41	-42	-42	-41	-42	-41	-41
33	-27	-27	-27	-26	-26	-26	-26
34	-4	-6	-7	-5	-7	-3	-5
35	-7	-8	-7	-11	-11	-12	-9
36	-60	-68	-81	-82	-128	-98	-98
37	-10	-13	-13	-15	-15	-16	-15
38	-16	-18	-23	-17	-21	-12	-16

Figure 1/ A View of Algoma Street Bridge

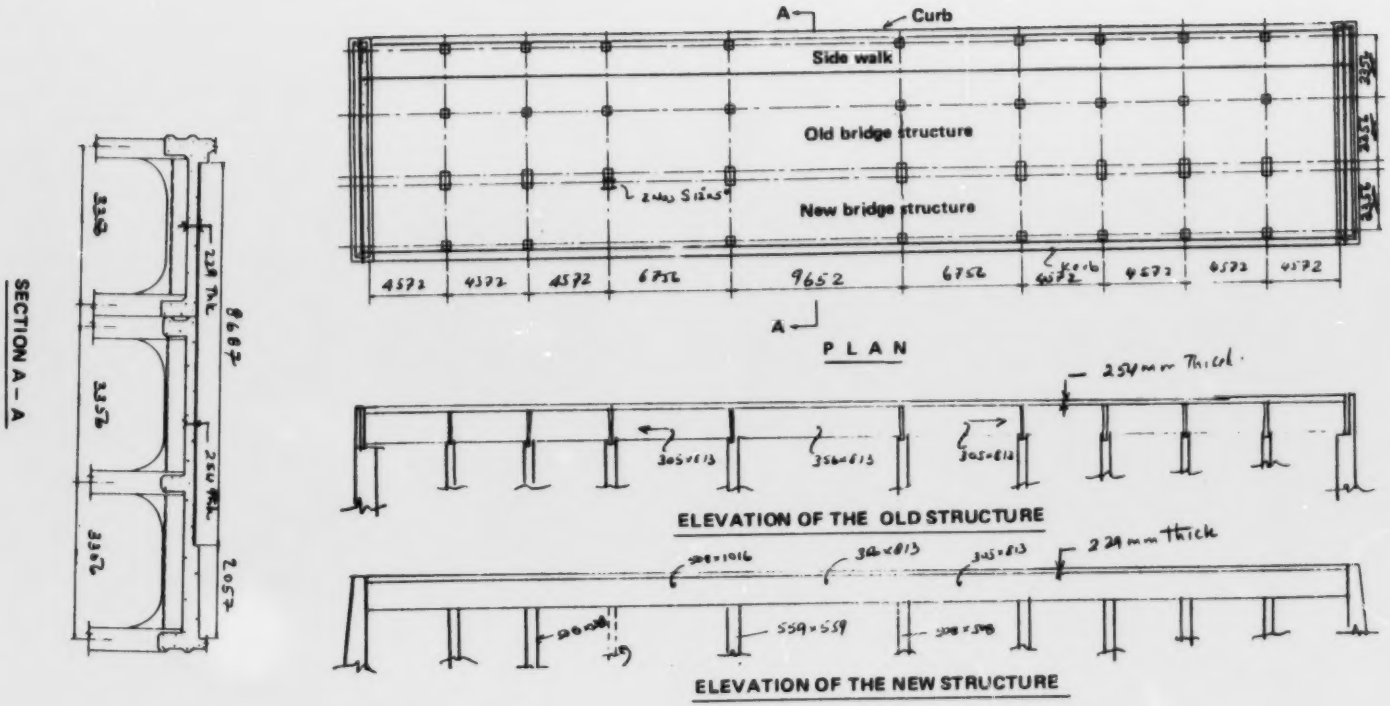


Figure 2/ Bridge Details

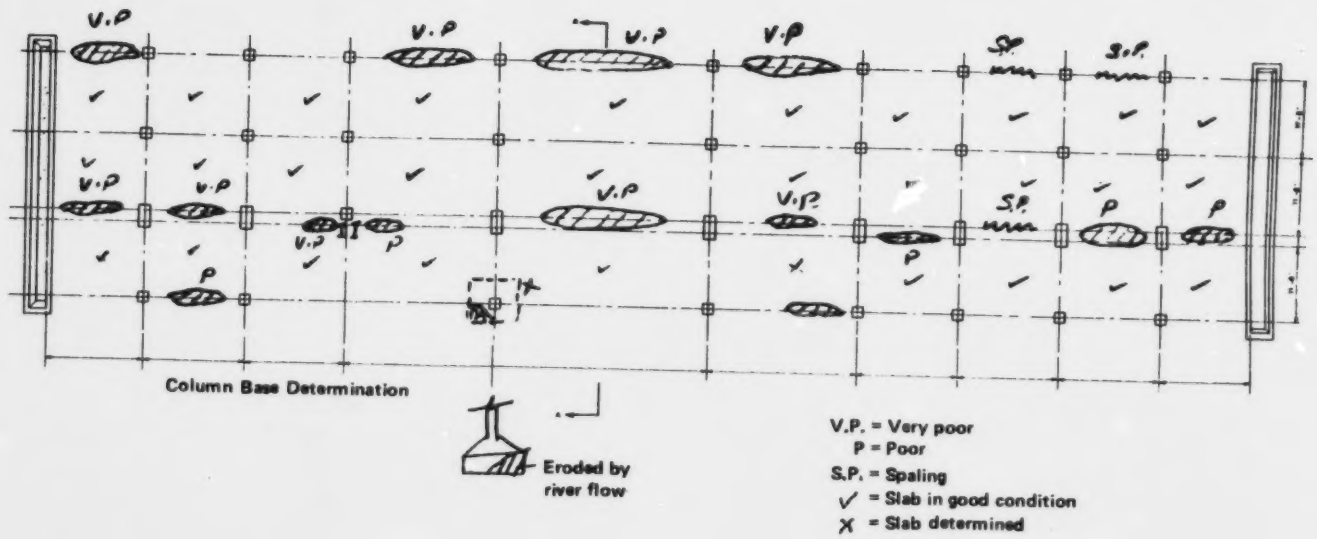
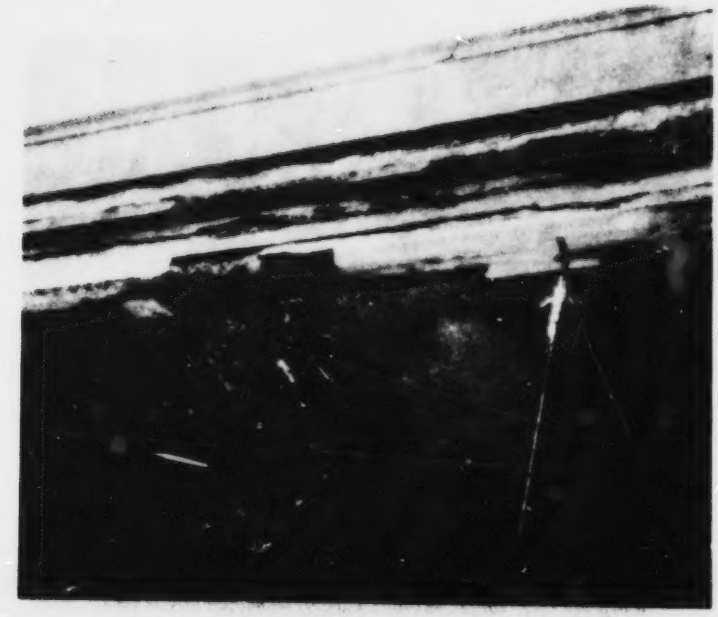


Figure 3a/ Condition Survey of Algoma Street Bridge



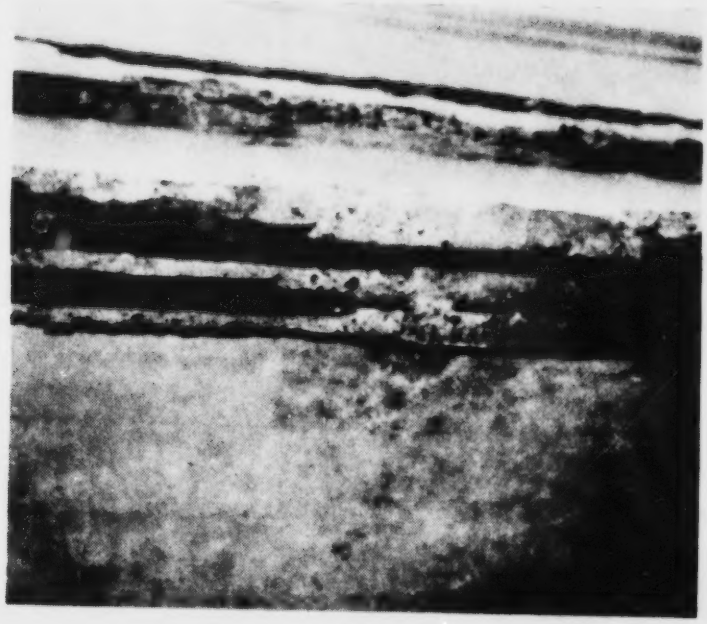


Figure 3b/ Typical Beam Deterioration Observed

3c/ Load Posting on the Bridge

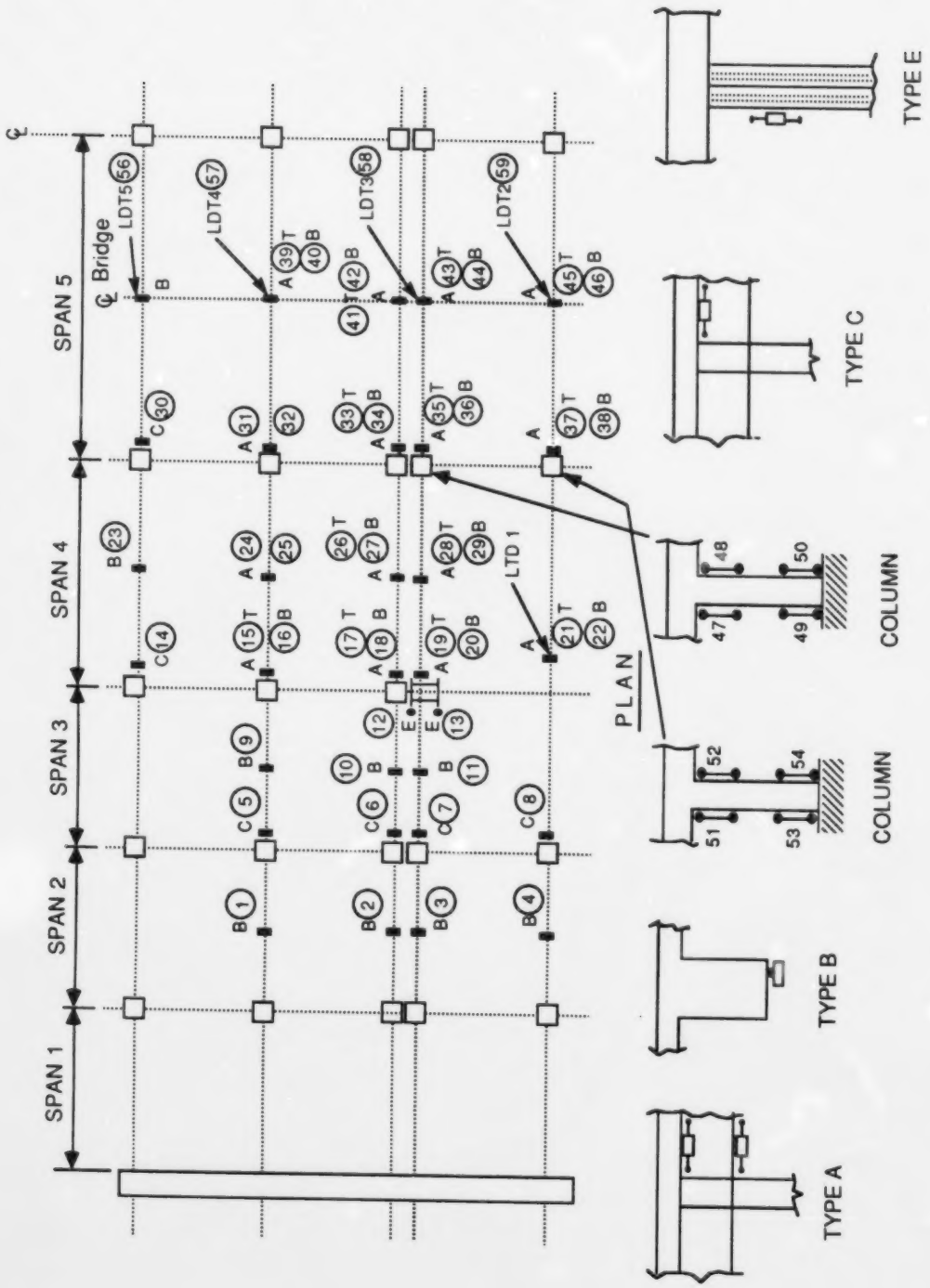


Figure 4/ Instrumentation Details

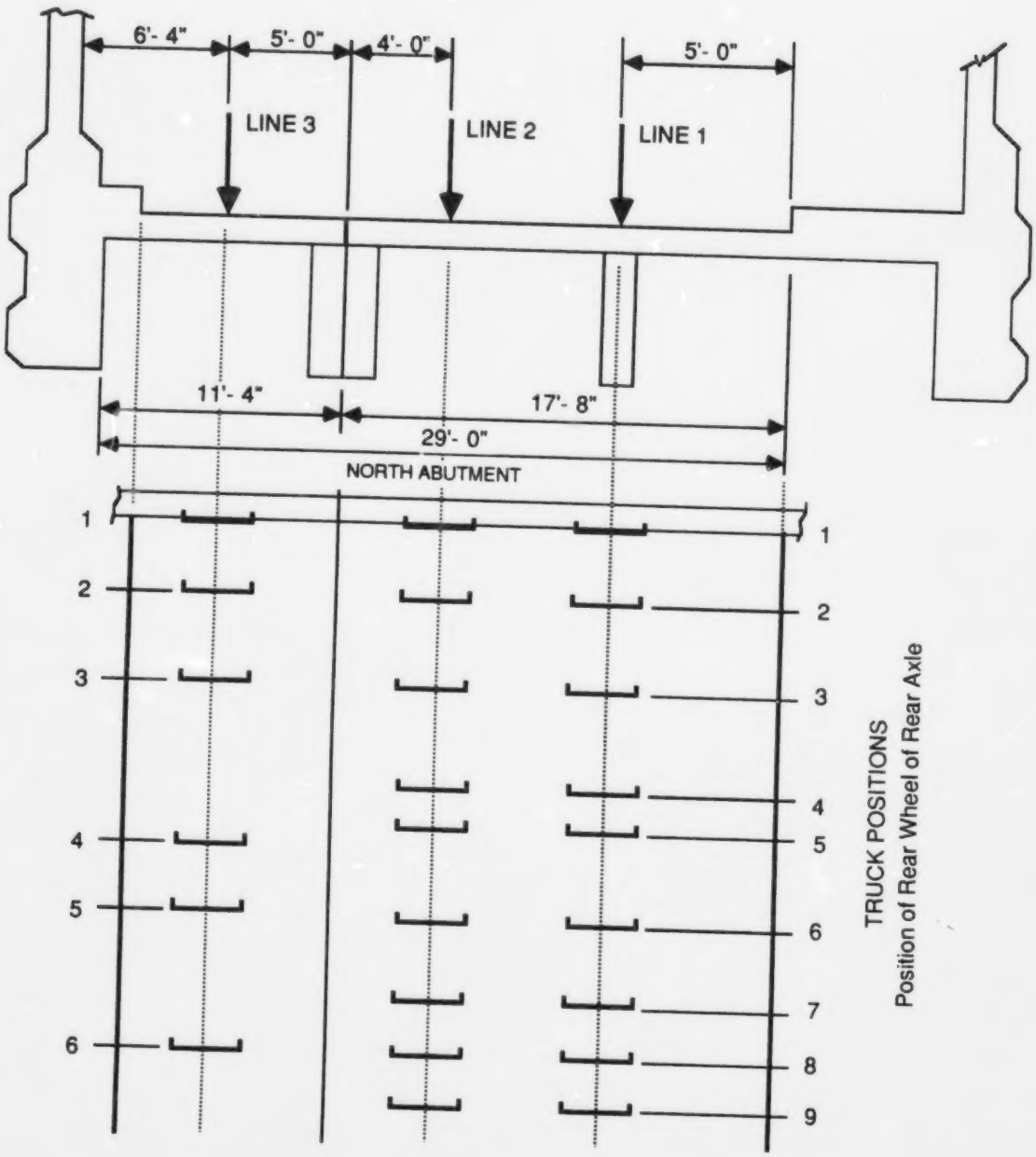


Figure 5/ Transverse and Longitudinal Truck Position